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Study on Underground Auger Mining Hazards

UNITED STATES DEPARTMENT OF THE INTERIOR
Mining Enforcement and Safety Administration
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U.S. Mining Enforcement and Safety Administration.

Informational Report 1010

Study on Underground Auger Mining Hazards

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UNITED STATES DEPARTMENT OF THE INTERIOR
Rogers C. B. Morton, Secretary

Mining Enforcement and Safety Administration
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STUDY ON UNDERGROUND AUGER MINING HAZARDS

by

R. H. Oitto[1] and R. R. McLellan[1]

ABSTRACT

The Technical Support Activity of the Mining Enforcement and Safety Administration programmed three consecutive studies of underground auger mining to identify hazards, determine why they exist, and recommend how they can be eliminated or reduced. Highlights are presented of the first two studies. One was made by the Pittsburgh Technical Support Center (PTSC) and the other was made under contract by Theodore Barry and Associates (TB & A). The third study, which is the subject of this report, was made by the Health and Safety Analysis Center of Technical Support.

Fatalities caused directly by underground auger machines have decreased significantly but not because the hazards from auger machines have been lessened. Rather, the exposure time to the hazards has been decreased through emphasis on safer operating procedures and because many underground auger mines have closed.

INTRODUCTION

Theodore Barry and Associates' industrial engineering study of hazards associated with underground coal mine production, completed on January 31, 1972 under USBM Contract No. S0110601 MOD. 1-B, stated on page 5-1 that "the one piece of face equipment that accounted for the highest rate of fatalities per number of machines in the field is the auger continuous miner." That statement prompted Technical Support of the Health and Safety Division of the Bureau of Mines (Technical Support now is part of the Mining Enforcement and Safety Administration) to study underground auger mining to identify hazards, determine why they exist, and recommend how they can be eliminated or reduced.

In all, three consecutive studies were made. The Pittsburgh Technical Support Center of Technical Support made the initial study which consisted of reviewing auger mining by visiting underground auger mines and auger machine manufacturers.

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[1]Mining engineer, Health and Safety Analysis Center.

Next Theodore Barry & Associates, under contract, supplemented and complemented the PTSC review with a statistically oriented investigation of auger mining. TB&A emphasized summarizing and evaluating underground auger mining accident data for the 1966-1971 period to compare the degree and nature of auger mining hazards to other underground mining methods and to predict the trend in auger machine accidents.

The Health and Safety Analysis Center concluded Technical Support's underground auger mining study with an investigation designed to explore and expand the technical aspects of the TB&A findings and to arrive at solid, practical recommendations to upper level management in Health and Safety. Engineers of the Health and Safety Analysis Center (HSAC) obtained fresh input from visits to the Pittsburgh Technical Support Center, auger machine manufacturers, underground auger mines, and from analyses of auger mining accident data accumulated after 1971. Only those injuries unique to the auger machine, including its wire ropes and rope anchor jacks, were studied in detail. Other injuries resulting from causes such as roof falls and electricity, which are common to all underground coal mining methods, were bypassed expept when judged to be directly associated with the auger machine. For example, roof fall fatalities resulting from failure to follow the roof control plan or electrical fatalities resulting from not properly maintaining a trailing cable or an electrical box, were not charged to the auger machine.

AUGER-TYPE CONTINUOUS MINERS

Auger-type continuous miners were developed in the United States in the early 1950's. They were developed for one main purpose--continuous mining of low coal seams. Other continuous miners were already on the market but they were too high for low coal.

Two features make the auger-type continuous miner unique from other continuous miners and give it its low profile for thin-seam coal mining. One feature is a pair of parallel augers which tear the coal from the face and shove it rearward to a conveyor chain in the miner (fig. 1). The other feature is a skid plate on which the miner is moved around at the face. A system of sheaves and wire ropes anchored by jacks slides the miner forward, rearward, and sideways on its skid plate. With the skid plate instead of wheels or crawler-tracks, the auger miner is less than 2 feet high, making it suitable for low coal.

The auger miners's low profile remained unmatched by other continuous miners for more than 20 years. But now with stronger, tougher steel available for scaling down machine parts, some of the other continuous miners, that is, those with cutting heads and crawlers, also have low profiles. They have not, however, made much impact in low coal mines because they are more expensive than auger miners.

Two companies produce auger-type continuous miners. The Wilcox Manufacturing Company,[2] Beckley, W. Va., started production in 1954 and produced about 350 auger miners, of which approximately 200 are still operable.

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[2]Reference to specific brands, equipment, or trade names in this report is made to facilitate understanding and does not imply endorsement by the Mining Enforcement and Safety Administration.

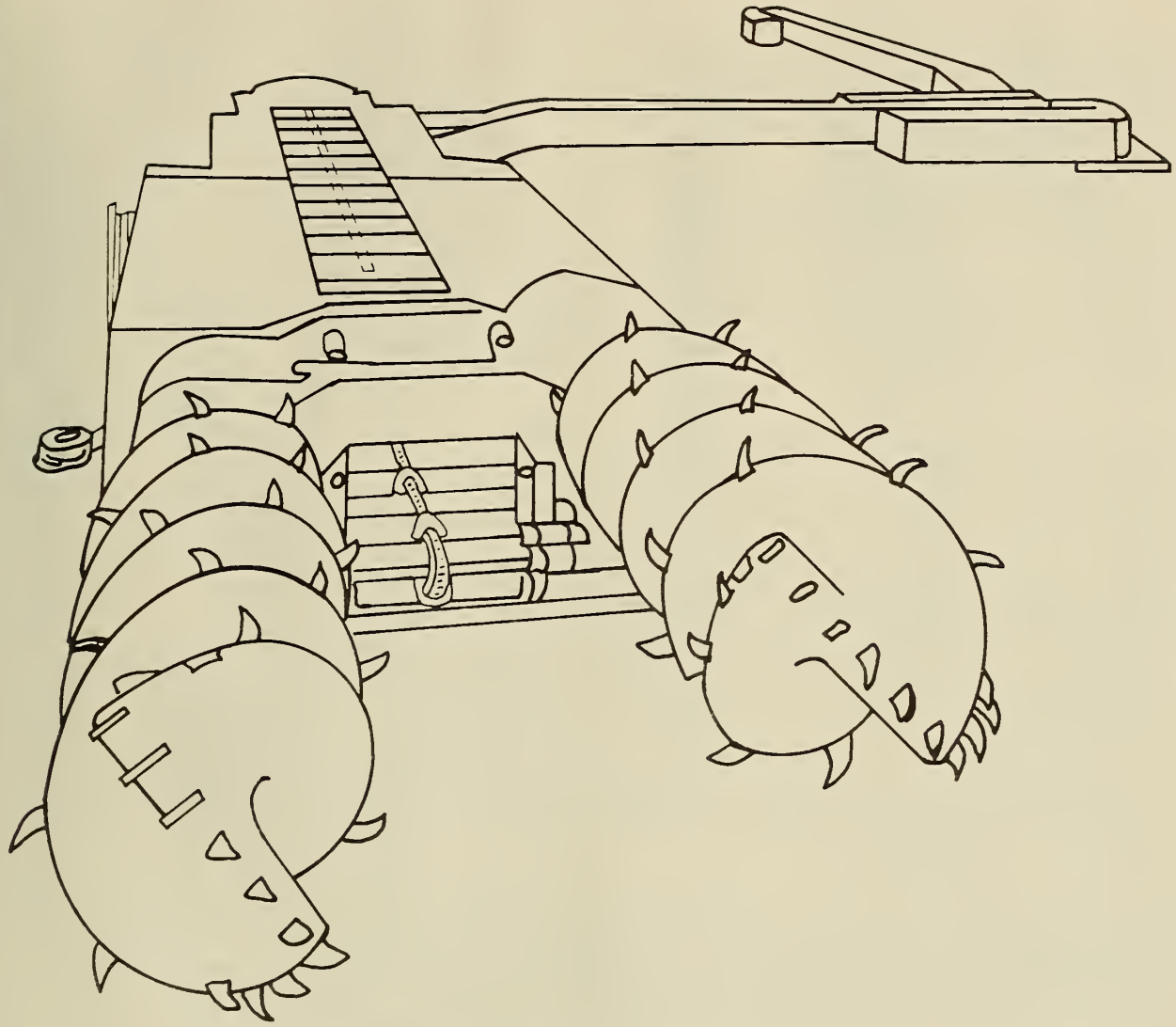

FIGURE 1. - Auger-type continuous miner.

The Jeffrey Mining Machine Company, Columbus, Ohio, started production in 1961 and has turned out about 200 auger miners, with about 125 still operable. The main differences between the Wilcox and Jeffrey auger miners are their shape and size (fig. 2). In plan, the body of the Wilcox miner is rectangular; the Jeffrey body is oval. The Wilcox miner is 2 feet narrower and 7 feet longer than the Jeffrey miner. Both miners are less than 2 feet high.

AUGER MINING METHOD

In a typical face operation, the wire ropes pull the miner forward into the coal at one side of the coal face (fig. 3). This is called sumping. After the augers are fully into the coal, the wire ropes are moved to the front sheaves and anchored at each side of the machine to pull it sideways to cut the coal across the face. Double acting rams raise and lower the two

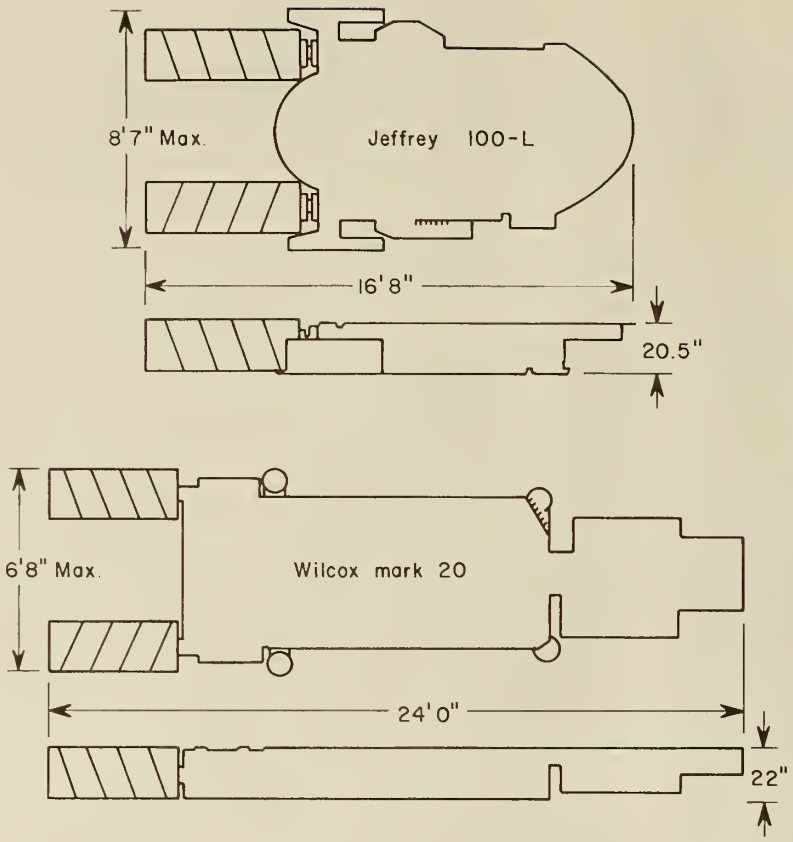

FIGURE 2. - Plan view of Jeffrey and Wilcox auger miners.

augers separately to cut the full height of coal as the miner moves across the face (fig. 4). After the face cut is completed, the miner is pulled into the coal face and then pulled back across the face to take another cut of coal. This repeated sumping and cutting of coal is called the sump-and-traverse method.

PITTSBURGH TECHNICAL SUPPORT CENTER STUDY

Engineers of MESA's Pittsburgh Technical Support Center (PTSC) started their study of underground auger mining during early 1972 and completed it during March 1972. Mining engineers G. A. Wanchek and G. C. Price, of Mine Safety Evaluation, visited several underground auger mines to delineate potential hazards. They visited auger miner manufacturers to discuss the hazards they had observed underground and auger miner modifications that might be practical to eliminate hazards. Based on the information obtained, they recommended safety practices and auger machine modifications to manufacturers and enforcement personnel and prepared three reports[3] describing their findings. Here are some examples of safety practices they recommended:

1. Prohibit shoveling near rotating augers.

2. Stop augers when work is performed inby front sheaves.

3. Stop augers when repositioning machine.

4. Alert entire crew before starting augers.

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[3]Memorandum to E. J. Harris, Acting Chief, PTSC, "Trip Report--Jeffrey Manufacturing Company," (March 10, 1972).
Memorandum to E. M. Kawenski, Chief, Mine Safety Evaluation, PTSC, Trip Report--Wilcox Manufacturing Company," (March 20, 1972).
Wanchek, George, and George Price. Preliminary Safety Analysis and Evaluation of Mining Practices Associated with Auger-Type Continuous Miners. Special Report, March 28, 1972.

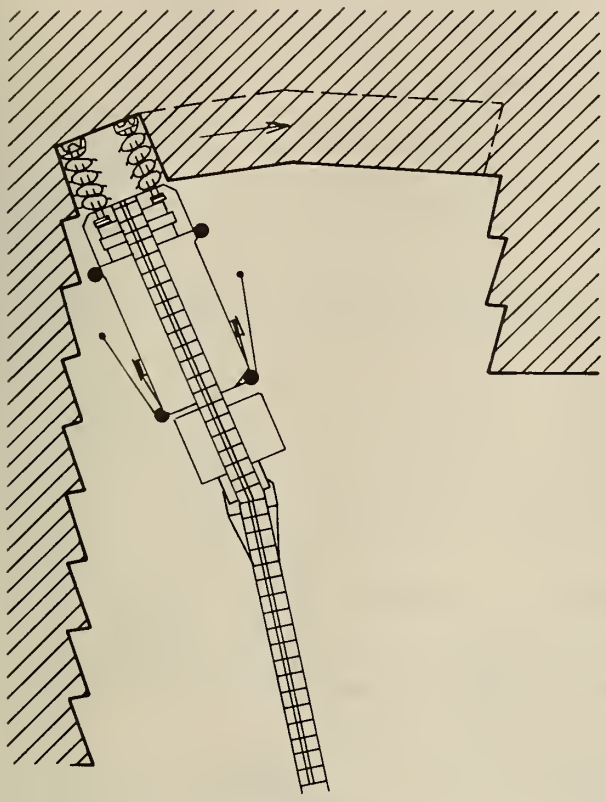

FIGURE 3. - Auger miner sumping into coal face.

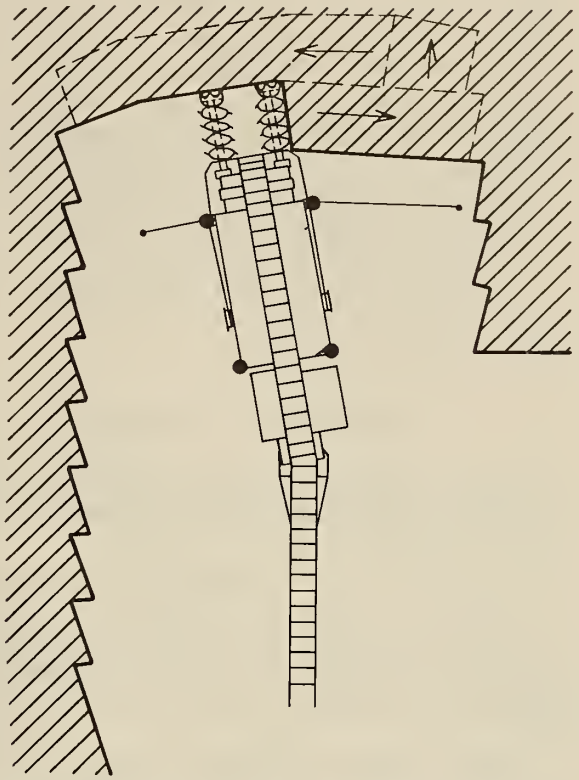

FIGURE 4. - Auger machine mining face cut.

5. Replace frayed wire rope before it breaks.

6. Lubricate sheaves regularly to prevent sticking and, consequently, rope wear.

Some machine modifications they suggested were:

1. Hydraulic clutch and brake assembly for augers with controls at operator's station.

2. Panic bar for emergency electrical and hydraulic cutoff.

3. Safety drag to prevent miner from skipping sideways if rotating auger snags roof or floor.

4. Warning alarm for auger start-up.

THEODORE BARRY & ASSOCIATES STUDY

Technical Support contracted with TB&A to make a statistically oriented study to supplement and complement PTSC's study. TB&A studied auger mining

during May through August 1972.[4] In that 4-month period heavy emphasis was placed on summarizing and evaluating underground coal mine fatal and nonfatal injuries for the 1966-1971 period to compare the degree and nature of underground auger mining hazards to other underground mining systems and to predict the trend in auger machine injuries. TB&S's efforts to summarize nonfatal injuries were only partially successful because not all nonfatal injuries for the 1966-1971 period were reported and those that were could not be cleanly categorized by mining method; that is, auger, conventional, and continuous methods other than auger.

Based on a variety of statistical analyses (correlation, multiple regression, cross-tabulation) of auger mining fatal and nonfatal accident data, TB&A concluded:

1. Accidents in underground auger mining would increase significantly.

2. The auger miner is the most dangerous piece of face equipment used in any low-coal continuous mining system.

3. The auger miner should be considered for immediate modification.

TB&A's prediction that accidents would increase in auger mining did not happen, fortunately. Why the increase did not materialize is explained later in the study made by the Health and Safety Analysis Center.

The second conclusion about the dangerousness of the auger miner is a TB&A hypothesis for which available data did not permit the analysis necessary to support or to disprove.

Some auger miner modifications recommended by TB&A were:

1. Mechanized sumping, cutting, and tramming ability to eliminate winching.

2. Remoted control of augers, pre-startup auger alarm, and automatic auger brake.

3. Effective coal pickup to minimize hand shoveling.

These are major modifications that would require research and development to implement and would substantially increase the cost of an auger miner.

TB&A's final report of the underground auger mining study lacked specific recommendations concerning what actions Health and Safety should take to alleviate safety hazards associated with auger mining machines. TB&A made general recommendations, mostly concerning machine modifications, but not in sufficient detail that would allow Health and Safety to take immediate and decisive action.

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[4]Theodore Barry and Associates, Summary and Evaluation of Underground Auger Mining Accident Data, USBM Contract Report S0122124, (August 31, 1972).

HEALTH AND SAFETY ANALYSIS CENTER STUDY

Objective and Procedure

The study by MESA's Health and Safety Analysis Center (HSAC) was designed to explore and expand the technical aspects of the TB&A study and to arrive at concrete, practical recommendations for upper level management personnel in MESA's coal mine Health and Safety Activity. After the final print of the TB&A report was received in February 1973, HSAC started its study and completed it in April 1973. Since then underground auger mining accident data have been updated quarterly by HSAC.

HSAC's study had three main steps:

1. Evaluate TB&A analyses and recommendations.

2. Evaluate machinery accident data acquired since completion of TB&A contract in August 1972.

3. Acquire new data and information from visits to:

    a. Pittsburgh Technical Support Center.

    b. Auger miner manufacturers.

    c. Auger mines.

    d. Enforcement groups.

The main thrust was at machinery accidents (item 2 above) because that category contained those injuries unique to the auger machine, including its wire ropes and rope anchor jacks. Other injury types such as roof falls, electricity, haulage, etc. were not analyzed in detail because they are common to all underground coal mining methods. For example, events such as failing to follow the roof control plan or to properly maintain a trailing cable or electrical box that result in a fatality are not the fault of the auger machine.

Analysis

Fatalities directly related to underground auger miners totaled 16 from 1966 through 1971, an average of about three per year. Most of the 16 deaths (90 percent) involved the augers. Generally, the victims were working near rotating augers or augers that started up and they were pulled or fell into the augers.

No fatalities caused directly by the auger machine occurred from August 2, 1971, to October 10, 1973, a period of 26 months. The fatality on October 10, 1973, resulted when a jack setter removed two safety posts in the way of extending the wire rope and was killed by a rock that fell from the roof. HSAC charged this fatality to the auger machine even though

the cause was a roof fall because the wire rope, which is unique to the auger machine, was involved.

The 26 month interval with no fatalities is statistically significant. Using basic statistical techniques, the Poisson distribution in particular, HSAC determined that the chance of no fatality occurring during the period was less than 1 percent, or in other words, there was greater than a 99-percent chance that a fatal injury would occur. Since none did, HSAC reasoned that something about auger mining must have changed during those 26 months to reduce the likelihood of having a fatal injury. What happened is described later.

During 1973 nonfatal lost time injuries caused by auger mining machines averaged six per month, a decrease of about 25 percent over 1972. Most of the nonfatal injuries have been caused by the wire ropes and the rope anchor jacks. Injuries from ropes result from handling frayed ropes and being struck by ropes that break or come loose. Injuries from the rope anchor jacks result from the jack falling while being set or pulling loose after being set, indicating that an easier method of installing jacks with a better anchor is needed.

The reduction in fatalities and the low number of disabling injuries are due to:

1. Reduction in number of underground auger mines.

2. Increased surveillance by inspectors.

3. Improved safety practices recommended by Pittsburgh Technical Support Center and accepted by operators and enforcement.

4. Training film by the Bureau's Division of Education and Training Services.

From May 1972 to May 1973, the number of underground auger mines decreased 33 percent as shown in table 1. How many mines there were prior to May 1972 would be a gross guess because underground auger mining data are inseparably intermixed with continuous mining data.

TABLE 1. - Number of underground auger mines and auger machines

Date	Census taker	Underground auger mines	Jeffrey machines	Wilcox machines	Total auger machines
May 1972..	TB&A	180	107	125	232
May 1973..	HSAC	120	77	89	166
% Decrease	-	33	28	29	28

Two events caused the decline in the number of underground auger mines. One event was the Federal Coal Mine Health and Safety Act of 1969. Most auger mines are small operations and many were unable to meet the cost increases

resulting from additional equipment, manpower, and mine modifications to meet requirements of the Act, and thus closed. The other event was the environmental restrictions placed on sulfur in coal burned by electric generating plants. Many auger mines were in high sulfur coal and lost their markets when the sulfur restrictions were imposed.

In the past few years the Federal coal mine inspection force expanded from 250 to approximately 1,300 while the number of coal mines decreased, resulting in more frequent inspection of coal mines, including underground auger mines, and stronger compliance with the 1969 Act.

Coupled with increased surveillance are improved safety practices recommended by the Pittsburgh Technical Support Center and accepted by inspectors and operators. The most beneficial recommendation is prohibiting working near rotating augers.

The Bureau's Division of Education and Training Services, also now a part of MESA, produced a widely distributed movie "Safety Practices in Low Coal Mines" which includes some dramatic footage of the hazards of working around an auger miner. That movie has been seen by many auger mine crews and perhaps made an impression.

BENDIX CORPORATION CONTRACT

Some of the auger machine modifications proposed by PTSC and TB&A have been investigated by the Bendix Corporation as part of Contract No. H0133031 "Production of Equipment Design Criteria for Panic Bars on Continuous Miners, Auger Miners, and Battery Mine Tractors." Modifications investigated are:

1. Redesign the auger clutches to allow immediate disengagement of the augers;

2. Redesign the clutch levers so that they can be located at the miner operator's control panel to provide the operator with complete and immediate control over the starting and stopping of the augers;

3. Design a warning and delayed start-up device for the augers so that anyone near the augers will be alerted to their being started and have time to move away.

The final report[5] by Bendix Corporation provides recommendations for design changes to improve auger rotation control on the Wilcox and Jeffrey auger miners.

WILCOX CONTINUOUS ARC AUGER MINER

The Wilcox Manufacturing Company has developed and in March 1973, marketed[6] a new auger miner called the Wilcox Mark 20 PJ continuous arc miner.

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[5]Bendix Aerospace Systems Division, Auger Miner Safety Study, Final Report BSR 4113 (January 1974).

[6]Coal mining and Processing, March 1973, p. 20.

The Mark 20 PJ eliminates sumping, the mining step that puts the jack setters forward of the pull ropes and near the rotating augers. Instead of sumping and then cutting across the face, the arc miner progressively cuts a series of arcs (figs. 5-7). Pivot jacks at the rear corners of the Mark 20 PJ make it self advancing. Extending one jack to the floor and the roof creates a pivot point. As the miner is pulled by a rope on the pivoting side, it

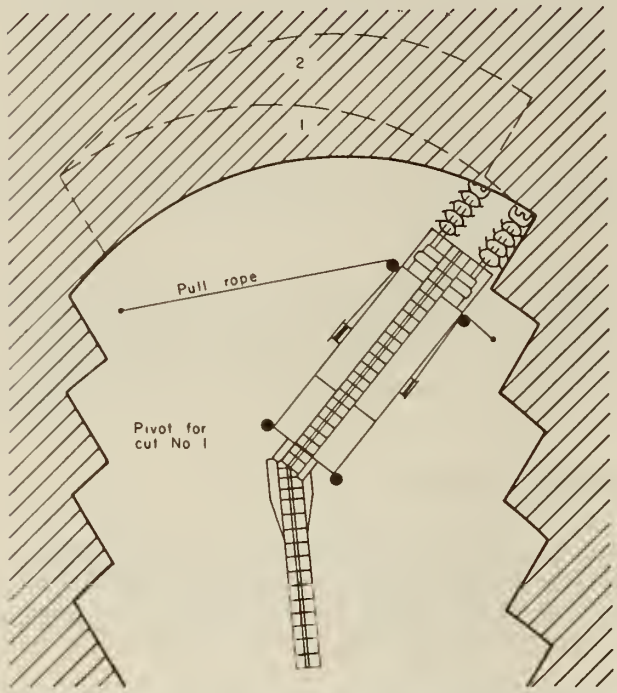

FIGURE 5. - Wilcox Mark 20 PJ auger miner starting arc.

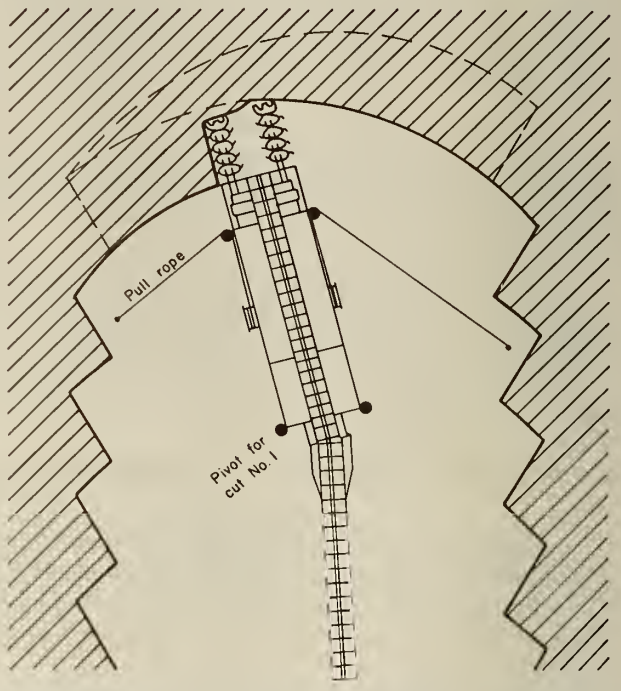

FIGURE 6. - Wilcox Mark 20 PJ auger miner midway in arc.

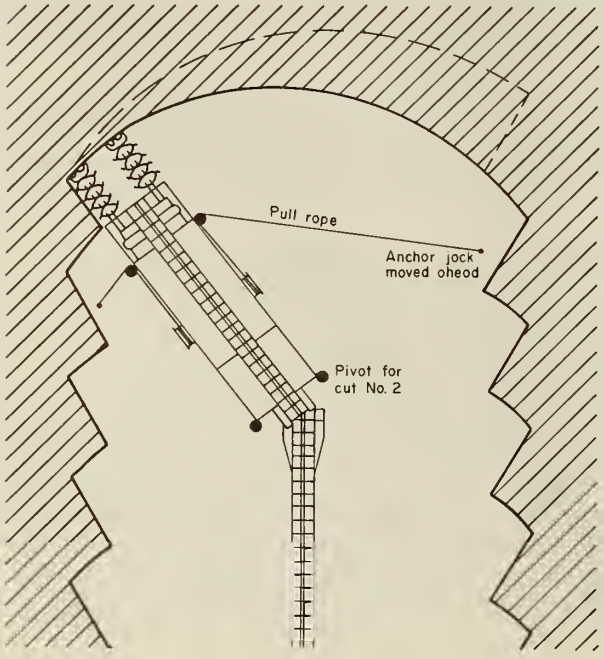

FIGURE 7. - Wilcox Mark 20 PJ auger miner ready for next arc.

swings on the pivot and moves forward. By alternately setting the pivot jacks and pulling the miner toward a rib, the miner advances forward, progressively cutting arcs. Wilcox claims that the semi-circular face offers better roof support and ventilation. Permanent roof supports can be installed closer to the face for greater safety because only the front end of the miner swings. Jack setter-face men are no longer required because anchor jacks are set by roof support men.

HSAC CONCLUSIONS AND RECOMMENDATIONS

1. Statistically, the auger continuous miner is not the most dangerous piece of face equipment as claimed by TB&A. This statement is based on zero fatalities caused directly by the auger machine from August 2, 1971, to October 10, 1973, a period of 26 months. The hazards of the auger machine have not been lessened, however. Rather the exposure time to the hazards has been decreased through emphasis on safer operating procedures and because more and more underground auger mines have closed. The rotating augers--the main hazard--are still there ready to snag and grind to death the momentarily careless or forgetful worker who strays alongside them.

2. Disabling nonfatal injuries associated with the auger machine average six per month and are caused mostly by the rope anchor jacks and the wire ropes.

3. Proper, safe procedure for setting rope anchor jacks should be determined and documented for better training of jack setters.

4. Daily inspection and maintenance of wire ropes and sheaves by auger mine crews should be emphasized.

5. The continuous arc method of auger mining, a new method developed by the Wilcox Manufacturing Company to reduce exposure to rotating augers, should be evaluated.

6. The Bendix Corporation recommendations for design changes to improve auger rotation control on auger miners should be studied to determine if MESA should take positive action.

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